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CRASSULACEAN ACID METABOLISM IN SOUTH AFRICAN SUCCULENTS:

A PRELIMINARY INVESTIGATION INTO ITS OCCURRENCE IN VARIOUS FAMILIES

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Abstract

Thirty-five species of South African succulents belonging to twelve families were investigated for the occurrence of Crassulacean Acid Metabolism in a pilot survey. Of these only two showed high but thirteen appreciable acid formation in the dark.

Introduction

South Africa has a particularly rich succulent flora, but as with the other striking members of our indigenous plant population, very little is known of their physiology. For many years a phenomenon termed Crassulacean Acid Metabolism has been studied in succulents, and it is characterised by an increase in the organic acid content of the chlorophyll containing tissues in the dark and a decrease in light. It is definitely associated with a conservation of carbon dioxide, which is converted into organic acid. The process is described in textbooks or in review articles as those of Ranson and Thomas (1).

Not all succulents show this Crassulacean Acid Metabolism (C.A.M.) and it is by no means clear how widely it is distributed among succulents. The succulent habit is found in many groups, so it is quite possible that a number of our major succulent families may not show this phenomenon. However, as no information was available in the literature, it was decided to investigate a few species of the major succulent families in an effort to establish the general behaviour pattern. No effort was made to undertake very accurate or reproducible work at this stage, as a general pattern was first sought. Hence techniques were reduced to the simplest possible and the results obtained were only semi-quantitative. They did give some information about the distribution of this Crassulacean Acid Metabolism in the South African flora.

Methods

A small number of succulent leaves (or where appropriate, some stems) were picked in the evening, or first thing in the morning and placed in a deep freezer to stop all further chemical reactions. When convenient, the leaves were rapidly cut into small pieces and placed in a homogeniser for 5—10 minutes depending on their texture, which determined the duration of this stage of the process.

If the extract was mucilaginous, it obviously could not be filtered and so was centrifuged at 1,700 G for 5 minutes. The supernatant liquid was collected and the precipitate was again well shaken up with distilled water and centrifuged. This was done four times. The supernatant liquids contained the acids.

If the homogenised solution was clear, then it was simply filtered, care being taken to see that the residue was properly washed.

In both cases the residues were carefully removed and dried in the oven to give the "dry weight" of the tissue. This dry weight was a convenient figure but it does not represent the "total dry weight" of the tissue as a water extract has been made and water soluble components including acids removed.

The filtrate was made up to a known volume, poured into a white evaporating dish to facilitate detection of colour changes. 1% phenolphthalein in 70% ethanol was used as an indicator. 0·01 N NaOH was titrated into this solution. The acid present was determined in milli-equivalents of acid. As the "dry weight" was known it was simple and meaningful to express changes in acid concentration as percentages of the daytime concentration.

RESULTS

Each species was sampled at least three times and the results averaged. In general this gives a reasonable insight into the C.A.M. status but in some cases, such as *Senecio cephalophorus*, very inconsistent results were obtained ranging from +761% to −65%. This was unusual. One plant *Lampranthus blandus* gave quite clear cut acid fixation in some samples and in other samples showed just as definite a loss of acid. This inconsistency, as some others which undoubtedly deserve further study, was not investigated any further.

As the investigations were undertaken upon material growing in winter (w) when conditions were cold and in spring (s) when they were much warmer, no real comparison can be made. However, it was possible to determine if the plants showed signs of C.A.M., and whether this was reasonably pronounced. The following symbols were allocated in Table 1:

+ up to 30% increase in the total acids during the dark
++ up to 30—60% increase in the total acids during the dark
+++ Plus over 60% increase in the total acids during the dark
— decrease of up to 30% increase in the total acids during the dark.

In fact only +++ plants need be regarded as showing significant C.A.M. and of these only one of the plants investigated, *Kleinia tomentosa*, shows a really high level of acid formation at 3421%. The next highest level of C.A.M. observed was in *Conophytum flavum* with 523%. Very few of the others exceed 100%.

CONCLUSIONS

Table 1 gives the results in tabular form. It is clear that many of the South African succulents show some degree of C.A.M but on the basis of this survey only a few show very high levels of acid formation. However, as these investigations were done out of doors in winter (w) and spring (s) it must be clear that conditions were not ideal for acid synthesis and all species with +++ must be regarded as plants with a high potential acid formation. *Kleinia tomentosa* and *Conophytum flavum* both show high levels of acid. Many of the species

TABLE 1
Crassulacean Acid Metabolism Rating of Some South African Succulents

Family	Species	C.A.M. Rating	Season
Aizoaceae	Carpobrotus edulis L. (N.E.Br.)	—	s
	Conophytum flavum N. E. Br.	+++	s
	Dorotheanthus bellidiformis (Burm.) N. E. Br.	——	w
	Lampranthus blandus (Haw.) Schwantes	inconclusive	
	Lithops salicola L. Bol.	+++	s
	Mesembryanthemum sp.	++	w
	Tetragonia fruticosa L.	+++	w
	Trichodiadema barbatum Schwantes	+++	s
Asclepiadaceae	Ceropegia stapeliaeformis Harv.	—	s
	Fockea crispa K. Schum.	—	w
	Stapelia gigantea N. E. Br.	—	s
Chenopodiaceae	Salicornia meyeriana Moss.	+	w
Commelinaceae	Cyanotis nodiflora Kunth.	+	s
Compositae	Othonna barkeri Compton	+	w
	Senecio cephalophorus (Compton) Jacobs.	+++	s
	Kleinia tomentosa Haw.	+++	s
	Cotyledon sp.	+++	s
	Cotyledon ladysmithiensis v. Poelln.	+++	s
	Crassula macowaniana Schoenl. & Bak. f.	+++	s
	Rochea coccinea (L.) D.C.	+	w
Euphorbiaceae	Euphorbia ingens E. Mey	—	s
Geraniaceae	Pelargonium crithmifolium Smith	+++	s
	P. fulgidum Willd.	+	w
	Sarcocaulon patersonii DC.	+	w
Liliaceae	Aloe excelsa Berger	+	w
	Astroloba rugosa Roberts MS (= A. aspera Vitew)	++	s
	Gasteria excelsa Bak.	+++	w
	Haworthia zantneriana v. Poelln.	+++	s
	Poellnitzia rubriflora Vitew.	++	w
Loranthaceae	Viscum sp.	++	w
Portulaceae	Anacampseros papyraceae E. Mey.	—	s
	Portulacaria afra Jacq.	++	w
Santalaceae	Thesidium fragile Sond.	+	s
Vitaceae	Cissus hypoleuca Harv.	+++	s
	C. quadrangularis L.	—	s

Details in text

investigated only showed a moderate C.A.M. So far only the Asclepiadaceae appear to show no C.A.M. The data on the Euphorbiaceae is too scanty for comment.

The general picture of these conclusions is very similar to earlier unpublished work in these laboratories on Cape succulents which showed that many of the local species had a fairly weak but readily determinable C.A.M. Those with pronounced acid forming abilities in the field appear to be rare.

REFERENCES:

RANSON, S. L. and THOMAS, M. (1960). "Crassulacean Acid Metabolism" Ann. Rev. Plant Physiol. **11**: 81.